Semestrálne zadanie: Komunikácia s využitím UDP protokolu

by

Tomáš Meravý Murárik

at Faculty of Informatics and Information Technologies STU

Course: Computer and Communication Networks

Assignment object: Design and implement P2P(Peer to Peer) application using custom protocol built on top of UDP (User Datagram Protocol) in the transport layer of TCP/IP model. The application should allow 2 users to communication over local Ethernet network, including text transmission and exchange of files between computers (nodes) . Both nodes will work simultaneously as receiver and sender.

Table of Contents

Structure of protocol header]
Estabilishing connection:[1]	
Fragmentation:	
Error detection :	
Keep Alive:	
Data corruption simulation :	
Changes made during implementation :	
Example comunication:	
Program diagram:	
Conclusion:	

Structure of protocol header

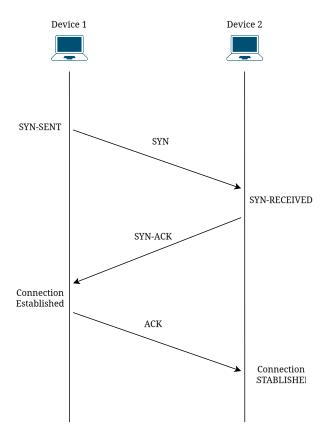
	32 bits					
flag	Current fragment number	Total num of fragments				
Total num of fragments	length	data 10-255				
data 10-255	crc16					

Estabilishing connection:[1]

Similaraly to TCP I will be using 3 way handshake using SYN-ACK system.

- 1. SYN) Both clients will be sending SYN packets to specified ports till one of the responds with SYN-ACK.
- 2. SYN-ACK)After SYN packet is recievied they will send back SYN-ACK packet acknowledging that they received SYN packet and is waiting for his ACK.
- 3. ACK) After client gets SYN-ACK packet he will respond with ACK packet completing the 3 way handshake.

Protocol uses the Flags field to signal which control state it's using.



Fragmentation:

Based on sequence number and fragment number, the program will determine how many packets it should expect and how it will reassemble the packet back together once all packets have been received.

Error detection:

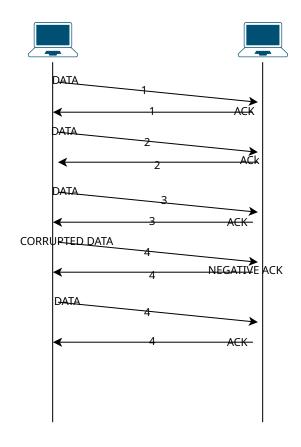
Using CRC16 the program will use checksum value to determine whether the received packet is corrupted or not.

CRC16:This algorithm uses 16 bit polynomial (divisor) to perform bitwise division on the data using binary xor operations where the remainder of there operation is appended at the end of the header . Same operation is performed by the receiver and if the receivers operation is equal to 0 , the client will return True saying that the data is intact . If the operation is not equal the algorithm will return False and the receiver will ask for the data again.

Reliable Data Transmission (ARQ):

After receiving each packet, the receiver sends an acknowledgment packet confirming successful reception. If the packet is corrupted, a negative acknowledgment (NACK) is sent, requesting retransmission. If a fragment is missing during larger data transfers, the receiver will ask for it using its sequence number, identifying the missing fragment.

Using Stop-and-Wait ARQ, the sender will wait for an acknowledgment (ACK) before sending the next packet. If the sender receives a NACK or times out waiting for an ACK, it will resend the packet until an ACK is received.



Keep Alive:

The keep-alive mechanism will periodically send messages (e.g., every 30 seconds) from the sender to the receiver to indicate that the connection should remain active. The receiver is expected to respond with an acknowledgment (ACK). If no ACK is received after several keep-alive attempts, the connection will be closed.

Data corruption simulation:

To check whether error detection and fragmentation works, the sender will have option to send bad packet on purpose by altering checksum so the error detection on the receiving end asks for the packet again.

Connection termination:

Connection will be terminated in a similar way to tcp where the sender will announce the connection termination with a FIN flag and will wait for receiver to respond with ack .

Changes made during implementation:

2 changes made during the making of this program were in error detection and in header structure.

- Error detection) Instead of comparing crc16 value of message except last 2 bytes on receivers end with crc16 of sender (last 2 bytes), I decided to compare crc16 of whole message to 0 which should be clear indicator if message is corrupted or not.
- Header length) In my previous protocol version I wanted to have header length of 1byte but after careful consideration I decided to make it into 2 bytes.

Example comunication:

Handshake: SYN-packet announcing that the client1 is ready to start communication

```
26 2.367806408 127.0.0.1 127.0.0.1
                                                                                                                                                                MYPROT...
                                                                                                                                                                                                                52 Overhead Message
              30 2.868375234 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
              31 2.874155051 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message 34 3.368982109 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
               73 6.494688970 127.0.0.1
                                                                                                       127.0.0.1
                                                                                                                                                           MYPROT...
                                                                                                                                                                                                          56 Data Message (Len: 4)
            74 6.495190395 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message 228 9.955391669 127.0.0.1 127.0.0.1 MYPROT... 57 Data Message (Len: 5)

    229 9.955880138
    127.0.0.1
    127.0.0.1
    MYPROT...
    52 Overhead Message

    230 9.956313551
    127.0.0.1
    127.0.0.1
    MYPROT...
    57 Data Message (Ler

                                                                                                                                                                                                          57 Data Message (Len: 5)
            231 9.957017980 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
            278 12.943085919 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message 279 12.943570316 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message 280 12.944014456 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
             10 0.647982416 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 1.836434018 147.175.160.237 1476434018 1476434018 1476434018 1476434018 1476434018 1476434018
              02 0 406446070 447 475 460 227 462 450 425 224 TCD 60 52740 442 FACKI Cog-4
> Frame 30: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
>-Linux cooked capture v1
>-Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
> User Datagram Protocol, Src Port: 12345, Dst Port: 12346
V-Overhead Message
         Flag: SYN (1)
          Fragment Number: 1
          Fragment Total: 1
          Message Length: 0
```

- Message: - Checksum: 0x0e35

SYN-ACK-packet telling the client2 is also ready to start communication

26 2.367806408				
	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
30 2.868375234	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
31 2.874155051	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
34 3.368982109	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
73 6.494688970	127.0.0.1	127.0.0.1	MYPROT	56 Data Message (Len: 4)
74 6.495190395	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
228 9.955391669	127.0.0.1	127.0.0.1	MYPROT	57 Data Message (Len: 5)
229 9.955880138	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
230 9.956313551	127.0.0.1	127.0.0.1	MYPROT	57 Data Message (Len: 5)
231 9.957017980	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
278 12.943085919	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
279 12.943570316	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
280 12.944014456	127.0.0.1	127.0.0.1	MYPROT	52 Overhead Message
10 0.647982416	147.175.160.237	162.159.135.234	TCP	68 52710 → 443 [ACK] Seq=1
17 1.836434018	147.175.160.237	162.159.135.234	TCP	68 52710 → 443 [ACK] Seq=
36 3.370134504	147.175.160.237	162.159.135.234	TCP	68 52710 → 443 [ACK] Seq=1
49 4.298046360	147.175.160.237	162.159.135.234	TCP	68 52710 → 443 [ACK] Seq=1
65 5.724737146	147.175.160.237	162.159.135.234	TCP	68 52710 → 443 [ACK] Seq=1
00 0 406446070	447 475 460 007	460 450 405 004	TOD	60 E2740 442 FACK1 Cog=4
>-Frame 31: 52 bytes of the control	v1 ersion 4, Src: 127.0.	0.1, Dst: 127.0.0.1	6 bits) on inter	face any, id 0
Linux cooked capture	v1 ersion 4, Src: 127.0.	0.1, Dst: 127.0.0.1	6 bits) on inter	face any, id 0
>-Linux cooked capture >-Internet Protocol Ve >-User Datagram Protoc	e v1 ersion 4, Src: 127.0. col, Src Port: 12346,	0.1, Dst: 127.0.0.1	6 bits) on inter	face any, id 0
Linux cooked capture Internet Protocol Ve User Datagram Protoc Overhead Message	e v1 Prsion 4, Src: 127.0 Pol, Src Port: 12346,	0.1, Dst: 127.0.0.1	6 bits) on inter	face any, id 0
Linux cooked capture - Internet Protocol Ve - User Datagram Protoc - Overhead Message - Flag: SYN-ACK (2)	e v1 Prsion 4, Src: 127.0 Pol, Src Port: 12346,	0.1, Dst: 127.0.0.1	6 bits) on inter	face any, id 0
Linux cooked capture - Internet Protocol Ve - User Datagram Protoc - Overhead Message - Flag: SYN-ACK (2) - Fragment Number:	e v1 Prsion 4, Src: 127.0 Pol, Src Port: 12346,	0.1, Dst: 127.0.0.1	6 bits) on inter	face any, id 0
Linux cooked capture - Internet Protocol Ve - User Datagram Protoc - Overhead Message - Flag: SYN-ACK (2) - Fragment Number: - Fragment Total: 1	e v1 Prsion 4, Src: 127.0 Pol, Src Port: 12346,	0.1, Dst: 127.0.0.1	6 bits) on inter	face any, id θ

ACK-packet from client1 telling client2 that they received their syn-ack packet successfully

```
26 2.367806408 127.0.0.1
                                                                 MYPROT...
                                                                                   52 Overhead Message
      30 2.868375234 127.0.0.1
                                          127.0.0.1
                                                                 MYPROT...
                                                                                   52 Overhead Message
      31 2.874155051 127.0.0.1
                                     127.0.0.1
                                                                MYPROT...
                                                                                   52 Overhead Message
                                   127.0.0.1
                                                                             52 Overhead Message
    34 3.368982109 127.0.0.1
                                                                MYPROT...
      73 6.494688970 127.0.0.1
                                         127.0.0.1
                                                                 MYPROT...
                                                                                   56 Data Message (Len: 4)
     74 6.495190395 127.0.0.1
228 9.955391669 127.0.0.1
                                    127.0.0.1
                                                                MYPROT...
                                                                                  52 Overhead Message
                                           127.0.0.1
                                                                 MYPROT...
                                                                                   57 Data Message (Len: 5)

    229 9.955880138
    127.0.0.1
    127.0.0.1

    230 9.956313551
    127.0.0.1
    127.0.0.1

                                                                MYPROT...
                                                                                 52 Overhead Message
                                                                 MYPROT...
                                                                                   57 Data Message (Len: 5)
     231 9.957017980 127.0.0.1 127.0.0.1
                                                                               52 Overhead Message
                                                                MYPROT...
                                    127.0.0.1
127.0.0.1
     278 12.943085919 127.0.0.1
                                                                             52 Overhead Message
52 Overhead Message
                                                                MYPROT...
     279 12.943570316 127.0.0.1
                                                                MYPROT...
                                          127.0.0.1
     280 12.944014456 127.0.0.1
                                                                MYPROT...
                                                                                 52 Overhead Message
     10 0.647982416 147.175.160.237 162.159.135.234 17 1.836434018 147.175.160.237 162.159.135.234
                                                                TCP
                                                                                  68 52710 → 443 [ACK] Seq=1
                                                                                 68 52710 → 443 [ACK] Seq=1
                                                                TCP
                                                               TCP
      36 3.370134504 147.175.160.237 162.159.135.234
                                                                                 68 52710 → 443 [ACK] Seq=1
      49 4.298046360 147.175.160.237
                                           162.159.135.234
                                                                TCP
                                                                                  68 52710 → 443 [ACK] Seq=1
                                                                                 68 52710 → 443 [ACK] Seq=1
      65 5.724737146 147.175.160.237
                                        162.159.135.234
                                                             TCP
> Frame 34: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
>- Linux cooked capture v1
> Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
User Datagram Protocol, Src Port: 12345, Dst Port: 12346
- Overhead Message
   Flag: ACK (3)
    Fragment Number: 1
    Fragment Total: 1
    Message Length: 0
    Message:
    Checksum: 0x8575
```

Sending not corrupted data:

PSH-4 :client2 (port:12346) is sending data to client1 and is immediately starting to listen for response

```
26 2.367806408 127.0.0.1
                                             127.0.0.1
                                                                     MYPROT...
                                                                                         52 Overhead Message
      30 2.868375234 127.0.0.1
                                             127.0.0.1
                                                                     MYPROT...
                                                                                         52 Overhead Message
      31 2.874155051 127.0.0.1
34 3.368982109 127.0.0.1
                                      127.0.0.1
127.0.0.1
                                                                     MYPROT...
                                                                                         52 Overhead Message
                                                                                    52 Overhead Message
                                                                     MYPROT...
    73 6.494688970 127.0.0.1 127.0.0.1 MYPROT... 56 Data Message (Len: 4)
       74 6.495190395
                        127.0.0.1 127.0.0.1
                                                                                          52 Overhead Message
     228 9.955391669 127.0.0.1
                                               127.0.0.1
                                                                                          57 Data Message (Len: 5)
                                                                      MYPROT...
                                                               MYPROT...
     229 9.955880138 127.0.0.1 127.0.0.1
                                                                                     52 Overhead Message
     230 9.956313551
                        127.0.0.1
                                               127.0.0.1
                                                                                          57 Data Message (Len: 5)
     231 9.957017980 127.0.0.1 127.0.0.1
                                                                                   52 Overhead Message
                                                                     MYPROT...

    278 12.943085919
    127.0.0.1
    127.0.0.1

    279 12.943570316
    127.0.0.1
    127.0.0.1

    280 12.944014456
    127.0.0.1
    127.0.0.1

                                                                     MYPROT... 52 Overhead Message
MYPROT... 52 Overhead Message
                                                                     MYPROT...
                                                                                        52 Overhead Message
      10 0.647982416 147.175.160.237 162.159.135.234 TCP 17 1.836434018 147.175.160.237 162.159.135.234 TCP
                                                                                         68 52710 → 443 [ACK] Seg=1 /
                                                                                         68 52710 → 443 [ACK] Seq=1 A
      36 3.370134504 147.175.160.237 162.159.135.234
                                                                                       68 52710 → 443 [ACK] Seq=1
      49 4.298046360 147.175.160.237 162.159.135.234 TCP
65 5.724737146 147.175.160.237 162.159.135.234 TCP
                                                                     TCP
TCP
                                                                                      68 52710 - 443 [ACK] Seq=1 7
68 52710 - 443 [ACK] Seq=1 7
> Frame 73: 56 bytes on wire (448 bits), 56 bytes captured (448 bits) on interface any, id 0
> Linux cooked capture v1
>-Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
> User Datagram Protocol, Src Port: 12346, Dst Port: 12345
- Data Message
    Flag: PSH (Data) (4)
    -Fragment Number: 1
    Fragment Total: 1
    Message Length: 4
    Message: ahoi
    Checksum: 0x0c2d
```

ACK: client1 successfully receibed the data and is telling the other client that everything went correctly

```
127.0.0.1
        26 2.367806408 127.0.0.1
                                                                                         MYPROT...
                                                                                                                  52 Overhead Message
                                                                                         MYPROT...
        30 2.868375234 127.0.0.1
                                                           127.0.0.1
                                                                                                                  52 Overhead Message
                                                  127.0.0.1
        31 2.874155051 127.0.0.1
                                                                                        MYPROT...
                                                                                                                52 Overhead Message
                                                                                                      52 Overhead Message
       34 3.368982109 127.0.0.1 127.0.0.1 73 6.494688970 127.0.0.1 127.0.0.1
                                                                                        MYPROT...
                                                                                         MYPROT...
                                                                                                                  56 Data Message (Len: 4)
       74 6.495190395 127.0.0.1 127.0.0.1
228 9.955391669 127.0.0.1 127.0.0.1
                                                                                                           52 Overhead Message
                                                                                        MYPROT...
       228 9.955391669 127.0.0.1
                                                                                         MYPROT...
                                                                                                                  57 Data Message (Len: 5)
                                                                                                                52 Overhead Message
      229 9.955880138 127.0.0.1 127.0.0.1
                                                                                        MYPROT...
                                                                                    MYPROT... 52 Overhead Message
TCP 68 52710 – 443 [ACK] Seq=1,
TCP 68 52710 – 444
       230 9.956313551 127.0.0.1
                                                           127.0.0.1
      231 9.957017980 127.0.0.1 127.0.0.1

    278 12.943085919
    127.0.0.1
    127.0.0.1

    279 12.943570316
    127.0.0.1
    127.0.0.1

      280 12.944014456 127.0.0.1
       280 12.944014456 127.0.0.1 127.0.0.1
10 0.647982416 147.175.160.237 162.159.135.234
        17 1.836434018 147.175.160.237 162.159.135.234
        36 3.370134504 147.175.160.237 162.159.135.234
49 4.298046360 147.175.160.237 162.159.135.234
        65 5.724737146 147.175.160.237 162.159.135.234
>-Frame 74: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
>-Linux cooked capture v1
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
> User Datagram Protocol, Src Port: 12345, Dst Port: 12346
Overhead Message
      Flag: ACK (3)
      Fragment Number: 4
      Fragment Total: 1
      Message Length: 0
      Message:
      Checksum: 0x3930
```

Sending corrupted data:

PSH-4 :client2 (port:12346) is sending corrupted data to client1 by adding +1 to checksum

```
26 2.367806408 127.0.0.1
                                                                                       127.0.0.1
                                                                                                                                   MYPROT...
                                                                                                                                                                         52 Overhead Message
            30 2.868375234 127.0.0.1
                                                                                       127.0.0.1
                                                                                                                                   MYPROT...
                                                                                                                                                                         52 Overhead Message
            31 2.874155051 127.0.0.1 127.0.0.1
                                                                                                                                  MYPROT...
                                                                                                                                                                        52 Overhead Message
                                                                                                                 MYPROT...
                                             127.0.0.1
            34 3.368982109
                                                                                        127.0.0.1
                                                                                                                                                                        52 Overhead Message
            73 6.494688970
                                                                                                                                   MYPROT...
                                            127.0.0.1
                                                                                        127.0.0.1
                                                                                                                                                                         56 Data Message (Len: 4)
           74 6.495190395 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
          228 9.955391669 127.0.0.1 127.0.0.1 MYPROT... 57 Data Message (Len: 5)
229 9.955880138 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
         229 9.955880138 127.0.0.1
                                                                                                                                   MYPROT...
          230 9.956313551 127.0.0.1
                                                                                       127.0.0.1
                                                                                                                                   MYPROT...
                                                                                                                                                                         57 Data Message (Len: 5)
          231 9.957017980 127.0.0.1 127.0.0.1 MYPROT...
                                                                                                                                                                        52 Overhead Message
         278 12.943085919 127.0.0.1
                                                                                    127.0.0.1
                                                                                                                                  MYPROT...
                                                                                                                                                                       52 Overhead Message
         279 12.943570316 127.0.0.1 127.0.0.1 MYPROT...
280 12.944014456 127.0.0.1 127.0.0.1 WYPROT...
                                                                                                                                                                 52 Overhead Message
                                                                                                                                  MYPROT...
                                                                                        127.0.0.1
                                                                                                                                                                        52 Overhead Message
           10 0.647982416 147.175.160.237 162.159.135.234
                                                                                                                                                                   68 52710 → 443 [ACK] Seq=1
                                                                                                                                  TCP
           17 1.836434018 147.175.160.237 162.159.135.234 TCP
                                                                                                                                                                    68 52710 → 443 [ACK] Seq=1 A
                                                                                       162.159.135.234
162.159.135.234
            36 3.370134504 147.175.160.237
                                                                                                                                  TCP
                                                                                                                                                                       68 52710 → 443 [ACK] Seq=1
           49 4.298046360 147.175.160.237 162.159.135.234 TCP 65 5.724737146 147.175.160.237 162.159.135.234 TCP 6.0.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.175.100.2014 147.100.2014 147.100.2014 147.100.2014 147.100.2014 147.100.2014 147.100.2014 147.100.2014 147.100
                                                                                                                                                                       68 52710 → 443 [ACK] Seg=1
                                                                                                                                                                     68 52710 → 443 [ACK] Seq=1
> Frame 228: 57 bytes on wire (456 bits), 57 bytes captured (456 bits) on interface any, id 0
 -Linux cooked capture v1
   Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
 -User Datagram Protocol, Src Port: 12346, Dst Port: 12345
- Data Message
        Flag: PSH (Data) (4)
        Fragment Number: 1
        Fragment Total: 1
        Message Length: 5
        Message: ahoi1
       Checksum: 0x8f5f
```

NACK : on receival of corrupted data the client 1 will respond with NACK message , telling the sending client that something went wrong.

```
MYPROT...
     26 2.367806408 127.0.0.1
                                       127.0.0.1
                                                                           52 Overhead Message
     30 2.868375234 127.0.0.1
                                       127.0.0.1
                                                          MYPROT...
                                                                          52 Overhead Message
                                     127.0.0.1
                                                          MYPROT...
                                                                           52 Overhead Message
     31 2.874155051 127.0.0.1
     34 3.368982109
                    127.0.0.1
                                       127.0.0.1
                                                          MYPROT...
                                                                           52 Overhead Message
     73 6.494688970
                    127.0.0.1
                                       127.0.0.1
                                                           MYPROT...
                                                                           56 Data Message (Len: 4)
    74 6.495190395 127.0.0.1 127.0.0.1
                                                      MYPROT...
                                                                     52 Overhead Message
    228 9.955391669
                                                          MYPROT...
                                                                           57 Data Message (Len: 5)
                    127.0.0.1
                                       127.0.0.1
                                                   MYPROT... 52 Overhead Message
    229 9.955880138 127.0.0.1 127.0.0.1
    230 9.956313551 127.0.0.1
                                  127.0.0.1
                                                          MYPROT...
                                                                           57 Data Message (Len: 5)
    231 9.957017980 127.0.0.1 127.0.0.1
                                                          MYPROT...
                                                                           52 Overhead Message
    278 12.943085919 127.0.0.1
                                       127.0.0.1
                                                          MYPROT...
                                                                           52 Overhead Message
                                                                        52 Overhead Message
    279 12.943570316 127.0.0.1
                                       127.0.0.1
                                                          MYPROT...
                                      127.0.0.1
    280 12.944014456 127.0.0.1
                                                          MYPROT...
                                                                           52 Overhead Message
     10 0.647982416 147.175.160.237
                                       162.159.135.234
                                                          TCP
                                                                           68 52710 → 443 [ACK] Seq=1
     17 1.836434018 147.175.160.237
                                       162.159.135.234
                                                                          68 52710 → 443 [ACK] Seq=1 /
                                                          TCP
     36 3.370134504 147.175.160.237 162.159.135.234 TCP
                                                                        68 52710 → 443 [ACK] Seq=1
     49 4.298046360 147.175.160.237 162.159.135.234 TCP 65 5.724737146 147.175.160.237 162.159.135.234 TCP
                                                                           68 52710 → 443 [ACK] Seg=1
                                                                           68 52710 → 443 [ACK] Seq=1 A
                                                                           60 E2740 442 FACKI CO.
Frame 229: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
 Linux cooked capture v1
 Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
 User Datagram Protocol, Src Port: 12345, Dst Port: 12346
Overhead Message
   Flag: NACK (6)
   Fragment Number: 5
   Fragment Total: 1
   Message Length: 0
   Message:
   Checksum: 0x0c85
```

Resending data:

PSH: upon receival of NACK packet, the sending client sends the data again.

```
26 2.367806408 127.0.0.1
                                      127.0.0.1
                                                         MYPROT...
                                                                         52 Overhead Message
     30 2.868375234 127.0.0.1
                                      127.0.0.1
                                                         MYPROT...
                                                                         52 Overhead Message
     31 2.874155051 127.0.0.1
                                     127.0.0.1
                                                                        52 Overhead Message
                                                        MYPROT...
                                127.0.0.1
                                                        MYPROT...
     34 3.368982109 127.0.0.1
                                                                       52 Overhead Message
     73 6.494688970 127.0.0.1
                                    127.0.0.1
                                                         MYPROT...
                                                                         56 Data Message (Len: 4)
     74 6.495190395 127.0.0.1 127.0.0.1
                                                    MYPROT...
                                                                   52 Overhead Message
    228 9.955391669
                    127.0.0.1
                                      127.0.0.1
                                                         MYPROT...
                                                                         57 Data Message (Len: 5)
    229 9.955880138 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
                                                                 57 Data Message (Len: 5)
    230 9.956313551 127.0.0.1 127.0.0.1
                                                 MYPROT...
                                127.0.0.1
127.0.0.1
    231 9.957017980 127.0.0.1
                                                        MYPROT...
                                                                       52 Overhead Message
                                                                  52 Overhead Message
    278 12.943085919 127.0.0.1
                                                        MYPROT...
    279 12.943570316 127.0.0.1 127.0.0.1
                                                                      52 Overhead Message
                                                        MYPROT...
    280 12.944014456 127.0.0.1
                                     127.0.0.1
                                                        MYPROT...
                                                                        52 Overhead Message
     10 0.647982416 147.175.160.237 162.159.135.234
                                                                       68 52710 → 443 [ACK] Seq=1
                                                        TCP
     17 1.836434018 147.175.160.237 162.159.135.234 TCP
                                                                      68 52710 → 443 [ACK] Seq=1
     36 3.370134504 147.175.160.237 162.159.135.234 TCP
                                                                      68 52710 → 443 [ACK] Seq=1 /
     49 4.298046360 147.175.160.237 162.159.135.234 TCP
                                                                       68 52710 → 443 [ACK] Seq=1 A
     65 5.724737146 147.175.160.237 162.159.135.234 TCP
                                                                        68 52710 → 443 [ACK] Seq=1
                                                                        CO E2740 442 FACKI CO.
>-Frame 230: 57 bytes on wire (456 bits), 57 bytes captured (456 bits) on interface any, id 0
> Linux cooked capture v1
>-Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
 User Datagram Protocol, Src Port: 12346, Dst Port: 12345

√ Data Message

   Flag: PSH (Data) (4)
   Fragment Number: 1
   Fragment Total: 1
   Message Length: 5
   Message: ahoi1
   Checksum: 0x8f5e
```

ACK: When the receiving client finally receives correct data, he sends ack packet.

```
26 2.367806408 127.0.0.1 127.0.0.1
                                                              MYPROT...
                                                                                52 Overhead Message
     30 2.868375234
                     127.0.0.1
                                          127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
     31 2.874155051 127.0.0.1
                                        127.0.0.1
                                                              MYPROT...
                                                                                52 Overhead Message
     34 3.368982109 127.0.0.1 127.0.0.1
                                                              MYPROT... 52 Overhead Message
      73 6.494688970
                                                               MYPROT...
                                                                                 56 Data Message (Len: 4)
     74 6.495190395 127.0.0.1 127.0.0.1
                                                          MYPROT...
                                                                               52 Overhead Message
     228 9.955391669 127.0.0.1
                                          127.0.0.1
                                                              MYPROT...
                                                                                57 Data Message (Len: 5)

    229 9.955880138
    127.0.0.1
    127.0.0.1

    230 9.956313551
    127.0.0.1
    127.0.0.1

                                                              MYPROT...
                                                                                52 Overhead Message
                                                               MYPROT...
                                                                                57 Data Message (Len: 5)
     231 9.957017980 127.0.0.1 127.0.0.1
278 12.943085919 127.0.0.1 127.0.0.1
                                                                         52 Overhead Message
                                                       MYPROT...
                                                               MYPROT...
                                                                                52 Overhead Message
                                                                         52 Overhead Message
    278 12.943085919 127.0.0.1 127.0.0.1
279 12.943570316 127.0.0.1 127.0.0.1
                                                              MYPROT...
     280 12.944014456 127.0.0.1
                                          127.0.0.1
                                                              MYPROT...
                                                                                52 Overhead Message
     10 0.647982416 147.175.160.237 162.159.135.234
                                                                              68 52710 → 443 [ACK] Seq=1
                                                              TCP
     17 1.836434018 147.175.160.237 162.159.135.234
                                                              TCP
                                                                                68 52710 → 443 [ACK] Seq=1
      36 3.370134504 147.175.160.237
                                          162.159.135.234
                                                               TCP
                                                                                68 52710 → 443 [ACK] Seq=1
     49 4.298046360 147.175.160.237 162.159.135.234
                                                              TCP
                                                                                68 52710 → 443 [ACK] Seq=1
     65 5.724737146 147.175.160.237 162.159.135.234
                                                            TCP
                                                                                68 52710 → 443 [ACK] Seg=1
                                                                                60 F0740 440 FACKI Con-
> Frame 231: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
Linux cooked capture v1
 Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
 User Datagram Protocol, Src Port: 12345, Dst Port: 12346
V Overhead Message
   Flag: ACK (3)
    Fragment Number: 5
   Fragment Total: 1
    Message Length: 0
    Message:
   Checksum: 0x4f84
```

Ending connection:

FIN-If client one of the clients decides to end the conversation, he sends a FIN-packet telling the other end that he intends to stop the communication.

```
26 2.367806408 127.0.0.1
                                          127.0.0.1
                                                               MYPROT...
                                                                                 52 Overhead Message
      30 2.868375234 127.0.0.1
                                          127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
      31 2.874155051 127.0.0.1
                                          127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
     34 3.368982109 127.0.0.1
73 6.494688970 127.0.0.1
                                          127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
                                          127.0.0.1
                                                               MYPROT
                                                                                56 Data Message (Len: 4)
     74 6.495190395 127.0.0.1
                                       127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
     228 9.955391669
                     127.0.0.1
                                          127.0.0.1
                                                               MYPROT...
                                                                                57 Data Message (Len: 5)
    229 9.955880138 127.0.0.1
                                         127.0.0.1
                                                               MYPROT
                                                                                52 Overhead Message
     230 9.956313551 127.0.0.1
                                          127.0.0.1
                                                                                57 Data Message (Len: 5)
                                                               MYPROT...
                                  127.0.0.1
    231 9.957017980 127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
                                  127.0.0.1
    278 12.943085919 127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
     279 12.943570316 127.0.0.1
                                         127.0.0.1
                                                                                52 Overhead Message
    280 12.944014456 127.0.0.1
                                          127.0.0.1
                                                               MYPROT...
                                                                                52 Overhead Message
     10 0.647982416 147.175.160.237
                                          162.159.135.234
                                                               TCP
                                                                                68 52710 → 443 [ACK] Seg=1
                                                                                68 52710 → 443 [ACK] Seq=1
      17 1.836434018 147.175.160.237 162.159.135.234
                                                              TCP
     36 3.370134504 147.175.160.237
                                                                                68 52710 → 443 [ACK] Seq=1
                                          162.159.135.234
                                                              TCP
      49 4.298046360 147.175.160.237
                                          162.159.135.234
                                                              TCP
                                                                                68 52710 → 443 [ACK] Seq=1
                                       162.159.135.234
      65 5.724737146 147.175.160.237
                                                                                68 52710 → 443 [ACK] Seq=1 A
                                                            TCP
> Frame 278: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
>-Linux cooked capture v1
>-Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
>- User Datagram Protocol, Src Port: 12346, Dst Port: 12345
Overhead Message
    Flag: FIN (5)
    Fragment Number: 1
    Fragment Total: 1
    Message Length: 0
    Message:
    Checksum: 0x0895
```

FIN: When client receives FIN packet, he sends one back and immedialy closes itself.

```
52 Overhead Message
      26 2.367806408 127.0.0.1
                                  127.0.0.1
                                                              MYPROT...
     30 2.868375234 127.0.0.1
                                          127.0.0.1
                                                              MYPROT
                                                                                52 Overhead Message
     31 2.874155051 127.0.0.1
                                         127.0.0.1
                                                              MYPROT...
                                                                                52 Overhead Message
                                  127.0.0.1
     34 3.368982109 127.0.0.1
                                                              MYPROT...
                                                                                52 Overhead Message
      73 6.494688970
                                          127.0.0.1
                      127.0.0.1
                                                              MYPROT...
                                                                                56 Data Message (Len: 4)
                                       127.0.0.1
     74 6.495190395 127.0.0.1
                                                              MYPROT...
                                                                              52 Overhead Message
     228 9.955391669 127.0.0.1
                                          127.0.0.1
                                                              MYPROT...
                                                                                57 Data Message (Len: 5)
                                   127.0.0.1
     229 9.955880138 127.0.0.1
                                                              MYPROT...
                                                                                52 Overhead Message
     230 9.956313551 127.0.0.1
                                                                                57 Data Message (Len: 5)
                                          127.0.0.1
                                                              MYPROT...
     231 9.957017980 127.0.0.1
                                   127.0.0.1
                                                              MYPROT...
                                                                                52 Overhead Message
    278 12.943085919 127.0.0.1
                                        127.0.0.1
                                                              MYPROT...
                                                                               52 Overhead Message
                                                                          52 Overhead Message
                                                              MYPROT...
     279 12.943570316 127.0.0.1 127.0.0.1
     280 12.944014456 127.0.0.1
                                                                                52 Overhead Message
                                          127.0.0.1
                                                              MYPROT..
     10 0.647982416 147.175.160.237 162.159.135.234
                                                              TCP
                                                                                68 52710 → 443 [ACK] Seq=1
     17 1.836434018 147.175.160.237
36 3.370134504 147.175.160.237
                                         162.159.135.234
                                                                                68 52710 → 443 [ACK] Seq=1
                                                              TCP
                                         162.159.135.234
                                                              TCP
                                                                               68 52710 → 443 [ACK] Seq=1
                                                              TCP
     49 4.298046360 147.175.160.237
                                       162.159.135.234
                                                                                68 52710 → 443 [ACK] Seq=1
      65 5.724737146 147.175.160.237
                                         162.159.135.234
                                                              TCP
                                                                                68 52710 → 443 [ACK] Seq=1
> Frame 279: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
- Linux cooked capture v1
>-Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
 User Datagram Protocol, Src Port: 12345, Dst Port: 12346
- Overhead Message
    Flag: FIN (5)
    Fragment Number: 1
    Fragment Total: 1
    Message Length: 0
    Message:
    Checksum: 0x0894
```

FIN: finally when the first client receives FIN, he closes itself (completing 3 way finishig handshake)

```
      26 2.367806408
      127.0.0.1
      127.0.0.1
      MYPROT...
      52 Overhead Message

      30 2.868375234
      127.0.0.1
      127.0.0.1
      MYPROT...
      52 Overhead Message

      31 2.874155051
      127.0.0.1
      127.0.0.1
      MYPROT...
      52 Overhead Message

      34 3.368982109
      127.0.0.1
      127.0.0.1
      MYPROT...
      52 Overhead Message

      73 6.494688970
      127.0.0.1
      127.0.0.1
      MYPROT...
      56 Data Message (Len

                                                                                                                                                                                                                                                                                                                                       56 Data Message (Len: 4)
                     74 6.495190395 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message

    228 9.955391669
    127.0.0.1
    127.0.0.1
    MYPROT...
    57 Data Message (Len: 5)

    229 9.955880138
    127.0.0.1
    127.0.0.1
    MYPROT...
    52 Overhead Message

    230 9.956313551
    127.0.0.1
    127.0.0.1
    MYPROT...
    57 Data Message (Len: 5)

      230 9.956313551
      127.0.0.1
      127.0.0.1
      MYPROT...
      57 Data Message (Len

      231 9.957017980
      127.0.0.1
      127.0.0.1
      MYPROT...
      52 Overhead Message

      278 12.943085919
      127.0.0.1
      127.0.0.1
      MYPROT...
      52 Overhead Message

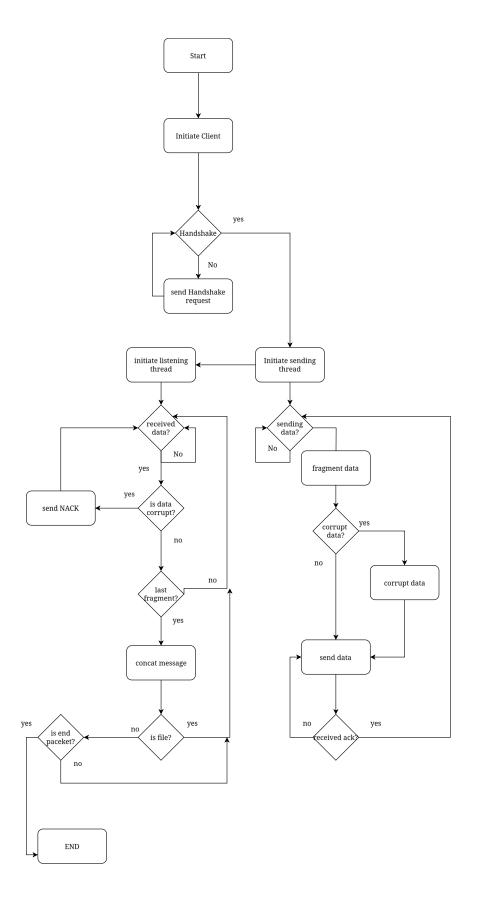
      279 12.943570316
      127.0.0.1
      MYPROT...
      52 Overhead Message

                  280 12.944014456 127.0.0.1 127.0.0.1 MYPROT... 52 Overhead Message
                     10 0.647982416 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 17 1.836434018 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 36 3.370134504 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 4.298046360 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 4.298046360 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 147.175.160.237 162.159.135.234 TCP 68 52710 - 443 [ACK] Seq=1 18 5.724737146 
> Frame 280: 52 bytes on wire (416 bits), 52 bytes captured (416 bits) on interface any, id 0
>-Linux cooked capture v1
>-Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
>-User Datagram Protocol, Src Port: 12346, Dst Port: 12345
- Overhead Message
                Flag: FIN (5)
                Fragment Number: 1
                Fragment Total: 1
                 Message Length: 0
```

Message:

Checksum: 0x0894

Program diagram:



11

Conclusion:

In conclusion, this project successfully implements a custom peer-to-peer communication protocol using UDP, ensuring reliable data transmission through features like a three-way handshake, CRC16 error detection, and fragmentation. This project all the basic requirements and successfully implements all mandatory conditions.

Bibliography

1: Nathan Jennings, Socket Programming in Python (Guide), 2022